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THE SOOTY MOULD OF CITRUS TREES: A STUDY IN POLYMORPHISM.

(Capnodium citricolum, n.sp.)

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(Communicated by J. H. Maiden, F.L.S.)

(Plates XXIII.-XXXIV.)

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This disease has been known for a long time, chiefly in Southern Europe, and now wherever Citrus trees are grown. It has had various common names in different countries, such as "Morfea," "Fumago," "Nero" in Italy; "Russthau or Sootdew" in Germany; "Sooty Mould" in Florida; and "Fumagine," "Black Mildew," "Black Blight" among ourselves. It is also often called "Smut" from its appearance, but does not belong to that division of Fungi which includes the true Smuts or *Ustilagineæ*. And the scientific names applied to it have been equally varied, for it assumes a variety of different forms to which different names have been given. In fact this "Sooty Mould" affords a very good illustration of what has been called Polymorphism—the same fungus appearing under different guises at different stages of its development, and it is this feature which will receive special attention here.

In order to prove the fact of polymorphism it would be necessary to sow pure cultures and watch the development of the different forms under strictly test conditions, for otherwise the forms found together might be really different, and constitute merely a case of association. It is quite conceivable that the exposed surface of an Orange or Lemon leaf might be invaded by a fungus forming a dense felt by the intertwining of its filaments, and this would entangle, like a spider's web, any other spores wafted thither, so that a small community of organisms might be established, not necessarily genetically connected.

Instead of making artificial cultures, however, I have simply examined a number of specimens under natural conditions from different parts of this colony, as well as New South Wales and South Australia, carefully noting the forms found in association; and when I find a series of forms regularly occurring and constituting this "Sooty Mould," no matter what colony the specimens come from, I am led to the conclusion that they form links in a chain of successive or contemporaneous forms of the same fungus. And I am strengthened in this belief by experiments made by Zopf* and others on closely allied species. "Zopf studied his plants chiefly in pure cultures on microscopic slides in nutrient saccharine solutions of various degrees of concentration, and ascertained the agreement of the cultivated forms with those which occur in nature."

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* N. Act. Leop. xl. 1878.

As already stated I have examined specimens from the three colonies of Victoria, New South Wales, and South Australia during the months of July and August. In Victoria I selected specimens from an orange tree in my own garden at Armadale; from another garden at Kew, a suburb of Melbourne; from the Royal Horticultural Gardens, Burnley; from a few other gardens; and from lemon trees grown on a large scale at Doncaster. The results obtained have been compared with those of South Australian and New South Wales specimens, and there is no doubt but the same fungus is common to all. The chief results will now be given from each district separately, to see how far similar forms are associated together in widely separated districts.

There is not only variety in the number of forms met with, starting with the gonidial and ending with the perithecial stage, but also in the different organs, and I have endeavoured to give some idea of this by representing variations in the characters of the self-same organs.

Victorian Specimens.

Doncaster specimens.—Doncaster is situated about 10 miles from Melbourne, where there is a well-known orchard with 23 acres mostly under lemon-trees, and in some situations and on certain trees there was abundance of the "Sooty Mould." The variegated lemon supplied the material, and as there was a greater variety of reproductive bodies met with than in any of the other specimens, it will be convenient to begin with it and give a general description of the fungus. It occurs on the living leaves particularly on the upper surface, but it may also appear more or less on the under surface. It is also on the branches as well as on the fruit, usually the upper or stem end as the fruits hang down. It forms black soot-like incrustations, often covering the entire upper surface of the leaf and peeling off in flakes. It is entirely superficial, not penetrating the tissues in any way, and therefore does not act as a parasite. There are all sorts of gradations in the nature and extent of the fungus. It may appear at first just like a sprinkling of dust on the leaf (in fact growers do confound it with dust), then of a dark muddy grey, peeling off as a thin papery layer, and finally as a sooty crust, soiling the fingers when rubbed. At times there is a considerable admixture of dust with the filaments, and then it is usually checked in its development. The depth of the colour is evidently largely influenced by the amount of more or less colourless and coloured hyphæ respectively, both of which are usually always present.

Fungus described.—When examined under the microscope it is seen to consist of a network of filaments and the reproductive bodies which they bear. These filaments are colourless or pale green, and darkly coloured, but there is a gradual transition from the one to the other. The thin-walled colourless filaments generally form a network in contact with the leaf, but they intermix with the thick-walled coloured filaments, and the more or less colourless may gradually become coloured, while the coloured may produce a colourless portion. When further developed, however, the colourless and the coloured hyphæ are distinctly seen.

Mycelium.—At an early stage the surface of the leaf shows numerous more or less colourless hyphæ creeping over it, and there are two kinds which may be distinguished—(*a*) closely septate, copiously branched hyphæ, in contact with each other and intermixing, so that a close-set pavement of cells is formed resembling a parenchymatous layer. The walls of these cells may become gelatinous, and thus not only stick together, but attach themselves more firmly to the epidermis of the leaf; and (*b*) at other times only creeping, colourless or pale green hyphæ are seen, very distantly septate and with their walls very uneven, as if thereby better able to adhere to the leaf. Even at this early stage there are abundance of colourless or pale green gonidia scattered about, which will be referred to subsequently.

When further developed the dark coloured hyphæ arise, and now there are the two kinds plainly discernible. The more or less colourless hyphæ are branched, septate, forming moniliform or elongated joints with mottled and usually vacuolated contents. The moniliform hyphæ averaged $3\frac{3}{4}$ μ in breadth, and the other, which were often of considerable length, $5\frac{1}{2}$ μ. Elongated and moniliform joints might occur in the same filament, but there were distinct, delicate, moniliform hyphæ and stouter hyphæ with elongated joints.

The dark coloured hyphæ are generally greenish-brown to dark brown, closely septate, either sparingly or copiously branched, thick-walled, bulging joints, often with oblique or longitudinal septa, $9\frac{1}{2}$-13 μ broad. The filaments often consist of several celled joints, and deeply constricted, so that their connection with each other is slight. The branches are very rigid, as may be seen when they are rolling about in a current, and the filaments anastomose as well as branch.

Reproductive bodies.—There is great variety in the mode of reproduction, and as this forms the distinguishing feature of the fungus it will be necessary to describe the different kinds with some fulness. The different forms are so unlike each other that the earlier mycologists assigned them to different form-genera, but they are now known to be stages in the life-cycle of the same fungus. The highest form or *Perithecium* will be described last, and this will enable us to fix the scientific position of the fungus.

(1) *Gonidia.*—These are produced in great abundance both by the colourless and coloured hyphæ, and no doubt contribute materially by their germination to weaving a web of hyphæ of firm texture. It will be convenient to consider them as produced by the colourless and coloured hyphæ.

(*a*) The gonidia produced by the colourless hyphæ at their tips are either colourless or pale green, and very varied. Some are in moniliform chains like a *Torula*, others spherical or oval and pale greenish, $7\frac{1}{2}$-$13 \times 3\frac{3}{4}$-$7\frac{1}{2}$ μ. Some are uniseptate and constricted at septa, 11-$19 \times 5\frac{1}{2}$-11 μ, others biseptate, about 24×8 μ.

A quadrate 4-celled body is very common, producing three radiating filaments, and bearing gonidia.

(*b*) The dark coloured hyphæ bear gonidia similarly coloured or a little paler, and are usually elliptical and uniseptate. They are very variable in size, $7\frac{1}{2}$-$16 \times 5\frac{1}{2}$-$8\frac{1}{2}\mu$. They are also in moniliform chains like a *Torula*, so that this form arises both from the transformation of the colourless and coloured filaments.

It has been shown by Zopf* that the ordinary joints of the dark coloured hyphæ are capable of germinating when detached.

(2) *Gemmæ.*—This is a convenient name for clusters of cells which detach themselves and reproduce the fungus. Detached portions of the coloured filaments, consisting of several joints and rounded at the ends, are very common. Also irregular groups of brown cells, which germinate and grow. Just as the genus-name of *Torula*, Pers., was applied to the moniliform chains of reproductive bodies, so the genus-name of *Coniothecium*, Corda, was given to the irregular groups of cells capable of germination. This form-genus would be represented both by the colourless quadrate bodies already referred to and the brown irregular clusters.

There are also green mulberry-like clusters of cells which are capable of germination and are really gemmæ, but they naturally belong to the next form.

It will readily be seen that between the *Torula* and *Coniothecium* forms there is no sharp line of demarcation. In the *Torula* chain a cell may divide in the different directions of space, and thus pass into the other form.

The multiplication of the fungus is so far amply provided for by means of gonidia, gemmæ and detached joints or mycelia, and even these may pass, according to Zopf, into resting states, if the supply of food slowly diminishes. But while the fungus might multiply abundantly by means of the above-mentioned forms alone, there are various other reproductive bodies to be noticed, so that its rapid spread and extensive diffusion need not excite surprise.

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* *L.c.* p. 13.

(3) *Glomeruli.*—I apply this term to pale or dirty green, or even brownish capsules, generally more or less spherical or hemispherical, and imbedded in and surrounded by the hyphæ. They are very common, and vary considerably in size from 75 to 470 μ in diameter. The surface is raised into minute rounded elevations, a structure easily accounted for on crushing and examination. They are often arranged in groups or in chains, and then they become somewhat polygonal from pressing against each other.

These capsules burst readily when ripe, and are found to consist of an outer green layer and inner colourless contents. The outer layer is composed of numerous clusters of green cells, each like a miniature mulberry, and measuring about 22 μ in diameter, hence the mammillated appearance of the surface. These clusters act like gemmæ and reproduce the disease on another Citrus-leaf, according to Penzig.* Inside this green shell are innumerable spherical, hyaline cells, large and small, imbedded in a gelatinous mass. They are either solitary or attached to each other by slender necks. The contents are turbid, with a relatively large vacuole, and while the larger are from 12-13 μ in diameter, the smaller are from 5-8 μ in diameter.

This has been assigned to the form-genus *Heterobotrys*, Sacc., and it is also found in connection with the "Sooty Mould" in Italy.

Penzig† describes and figures it as a stage in *Meliola penzigi*, Sacc., as a third conidial form, hitherto known as *H. paradoxa*, Sacc. It is interesting to observe that it is a different form of it we have in Australia, as the following account of the Italian form by Penzig will show (for the translation of which I am indebted to Dr. Gagliardi). He says:—" *H. paradoxa*, Sacc., appears to the naked eye as a small black globe, one-third of a millimetre in diameter, closely imitating the form of a perithecium. In fact, when we examine this small globe under the microscope, we can

* Annali di Agricoltura, p. 322, 1887.

† *L.c.* p. 321, and Atlas Pl. XXIV. fig. 4.

distinguish a parietal and a central part; but the parietal is not of solid structure, parenchymatous, as it consists of a number of dark coloured glomerules, just like those described as belonging to the second conidial form. In the centre of this pseudo-perithecium we find innumerable spherical cellules, large, discoloured, with delicate walls, and one or two small guttules in the interior, isolated or united by a very narrow ligature. The peripheric glomerules, as well as the central cellules, may reproduce, on germination, the 'morfea' on another leaf of a Citrus-plant." This is rather an economical form of reproductive-body, since the capsule itself, as well as its contents, is utilised in this way.

The Heterobotrys-stage is found both in Italy and Australia, with differences in detail, and it is conclusively proved, chiefly from the New South Wales specimens, that it is derived from the colourless or pale green filaments of the fungus. The coloured hyphæ give rise to several other reproductive bodies, which are generally recognised as of three kinds—Spermogonia, Pycnidia and Perithecia—but when a number of specimens are examined it is not always easy to assign the forms met with to these three categories. In the present instance, if we compare the forms with those of allied and known species such as *Capnodium salicinum*, Mort., there is no difficulty with the perithecia from their containing Asci, nor with the regular pycnidia and their septate stylospores or pycnospores; but there is a residue of forms which cannot, with any show of consistency, be all considered as spermogonia. And the settlement of the question is not rendered easier by the fact that one branch of the pycnidium in *C. salicinum* may produce spermatia and another branch pycnospores.* There are at least three sufficiently distinct kinds with unicellular spores, and although we have not applied the test which De Bary lays down, that spermatia differ from spores in being incapable of germination, still the one which approaches nearest to the general type of a spermatia-bearing organ will be reckoned as such.

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* Sorauer's Pflanzenkrankheiten, p. 336, 1886.

One of these three will be regarded as a spermogonium and the other two as gonidial receptacles or pycnidia, so that there will be three forms of pycnidia distinguished—(1) what may be called the *Antennaria-form*, with colourless, oval, unicellular spores; (2) the *Cerato-pycnidial-form*, with colourless, rod-like, unicellular spores; and (3) the *Pycnidial-form* proper, with coloured, pluricellular pycnospores.

(4) *Spermogonia.*—The so-called spermogonia with spermatia occur in great abundance along with the other forms. They were so named by Tulasne, but as no male sexual function has been demonstrated here, the name is a misnomer, but it may be retained for distinction' sake. De Bary, however, considers spermatia to be non-germinating gonidia, and that might serve to distinguish them.

The spermogonia are dark coloured bodies, usually green by transmitted light, oblong, ovate or oval in shape, rounded and smooth at the free end, with irregularly netted surface. They vary in size from 62-190 by 37-77μ.

The spermatia are hyaline, rod-like, minute, 4-5½ × 1-1½ μ.

(5) *Antennaria.*—These are dark green or brownish bodies, variable in shape and size, which may be swollen and flask shaped, with a short neck, or elongated oval or hemispherical, and opening irregularly at the apex. The contained spores are quite distinct from those of any of the other reproductive bodies, and I have utilised the genus-name of Antennaria, which is now generally regarded as a stage in the development of *Capnodium.* They are generally in clusters, dark green in colour, with decidedly marked walls, from 75-122 by 70-112 μ. Sometimes they are about as broad as long.

The spores are hyaline, oval to ovate, with granular contents and 2-5-guttulate, imbedded in mucilage, 5½-6½ × 2½-5 μ, average 5½ × 4 μ. Their size, shape and nature of contents distinguish them from the spermatia.

(6) *Cerato-pycnidia.*—I use this name for pale green, greenish-brown to dark brown, often swollen and curved, irregularly

shaped and sometimes branching pycnidia. They are distinct in appearance and contents from the two preceding forms, and may be very common.

They are so varied in character that it is difficult to describe them generally, but a special form may be selected, as in fig. 6*a*. It is an elongated, irregularly shaped body, the lower three-fourths of a pale green colour with a tinge of yellow, and the upper fourth of a decidedly darker tint. The upper fourth is slightly swollen and tapering towards the free end, with a round opening at the very apex, and contains the spores.

The lower portion tapers towards the base and bulges on one side towards the centre, after which it narrows into the upper portion. It is enveloped by and has hyphæ growing out from it, while the upper fourth is bare. The wall is faintly marked out into small irregular areas. The size is 240×75 μ, and the terminal smooth portion is 66×56 μ. There is no decided line of distinction between the upper and the lower portion, only the darker colour is confined to the upper portion.

Other specimens are common enough, which are just straight or curved cylindrical bodies, branched or unbranched, sometimes swollen at the base, and generally becoming paler in colour towards the tip. They may reach a length of 530 μ, and narrow down to a breadth between 20-30 μ. The wall is evidently composed of elongated, jointed filaments, arranged end to end. The spores escape by the opening at the apex, and are hyaline, rod-like, rounded at the ends, minute, imbedded in a gelatinous matrix, $4\text{-}6\frac{1}{2} \times 1\text{-}2$ μ, average about $5\frac{1}{2}\text{-}6 \times 1\frac{1}{2}\text{-}2$ μ. It will be observed that the spores resemble spermatia closely, but the capsule is different.

(7) *Pycnidia.*—These are not quite so common as the preceding in the specimens examined by me, but they are plentiful enough. They are generally somewhat flask-shaped or bottle-shaped bodies, branched or unbranched, dark coloured but often pale green towards the top, with walls resembling those of the preceding, and mouth usually fringed with hairs. There is considerable variety in the shape. It may be elongated and cylindrical, or

gradually tapering towards mouth, or swollen just below the opening. It may also be of a bright leek-green or greenish-brown or dark brown. The hairs fringing the mouth are simply tapering continuations of the cells of the walls, which are hyaline instead of being coloured. The pycnidia are sometimes very long, attaining a length of 670 μ.

The pycnospores are olive-green, pale yellowish-brown or yellowish. They are also colourless, but probably they pass from colourless to green, then to brown on maturity, like the sporidia. They are ovate to oval, or even cylindrical, generally 3- (sometimes 2- or 4-) septate, slightly constricted at the septa, and sometimes longitudinally divided, 15-22½ × 5½-9½ μ, average about 19-20 × 7½ μ. As already noticed, one branch may produce spermatia and the other pycnospores. I have observed no connection between spermogonia and pycnidia in their contents, but between the spermatia and the spores of cerato-pycnidia there is a close agreement.

(8) *Perithecia.*—They occur in large numbers at various stages of development, but none were found naturally opened. They are upright and deeply imbedded in the coloured hyphæ, so that their black-looking, rounded, upper portion is only distinctly seen. When crushed, the thick tough wall, as seen by transmitted light, is regularly of a characteristic sea-green or sage-green colour, and with a decided net-like surface.

They are oblong to oval or variously shaped, smooth in the upper portion, but often with adhering hyphæ in the imbedded portion, and varying in size from 112-250 × 52-112 μ.

The asci are hyaline, cylindrical-clavate in shape, sub-sessile, with rounded apex, 8- 6- 4-spored, and ranging from 49-81 × 15-20 μ. The fully mature asci average 70-80 × 19-20 μ.

The sporidia when mature are brown, oblong, sometimes a little fusoid, generally obtuse at both ends, constricted about the middle, 5-6-septate, often with longitudinal or oblique septa, arranged mostly in two ranks, but occasionally in three, and averaging 21-24 × 8½-9½ μ.

The paraphyses are hyaline, elongated-clavate, usually with finely granular contents, same length as ascus and 9½ μ. at broadest part.

The asci and paraphyses arise alongside of each other from short chains of colourless cells.

Asci were met with in various stages of development, and the sporidia pass through different coloured stages. At first the contents of the ascus are finely granular, almost completely filling the interior and having a small oval nucleus towards the centre. Then the differentiation of this homogeneous mass into colourless sporidia takes place. As they grow they assume a very pale green tint, and finally become brown, while they no longer fill the ascus, as the space between the topmost sporidium and the outer wall of the ascus may be 9½ μ.

It is worthy of note that these changes of colour from hyaline to *green* and from green to brown in the course of development of the sporidia may turn out to be characteristic features of the genus *Capnodium*. At any rate in the closely allied genus *Meliola* I found the sporidia to pass from hyaline to *yellow*, and from yellow to brown;* and in *Pleospora herbarum*, Pers., they are first hyaline, then yellowish, and finally yellowish-brown.†

Only a few mature sporidia were found, and as none of the perithecia met with had opened they are probably ripe as a whole later in the season.

The perithecia are the most characteristic of the reproductive bodies from their containing asci. They most resemble the spermogonia externally, but they are larger and less symmetrically shaped. They are quite distinct from the pycnidia, and yet Dr. Cooke in his recent excellent "Introduction to the Study of Fungi" (1895) has confounded them. He writes :—"The genus *Capnodium* is distinguished by elongated large perithecia,

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* Proc. Linn. Soc. N.S.W. 1896, Pt. 1, p. 104.

† On the Life-history of *Macrosporium parasiticum*, Thuem., by Kingo Miyabe. Ann. Bot. iii. No. ix. 1889.

which are often branched, and usually opening at the apex with a large fringed orifice. These are seated upon and amongst a dense subiculum of closely jointed or moniliform black hyphæ, so as to form large velvety patches, and are possibly, in some instances, the more complete developments of mould belonging to the genus *Fumago*." The accompanying figure of *Capnodium elongatum*, B. & D., with the spores leaves no doubt as to the pycnidium being meant. The pycnospores have a certain resemblance to the sporidia, but the latter have more septa, and of course are contained in asci (figs. 1-12).

Armadale Specimens.—Abundant examples were met with in my own garden, but only immature forms of perithecia were found. One side of the solitary orange-tree was decidedly less attacked than the other, and it was the most exposed and that which received most of the sun, the sheltered side receiving less of the sun being by far the worst.

Colourless and coloured hyphæ similar to the preceding were met with, and gonidia, gemmæ, glomeruli and antennaria forms.

Mycelium and Gonidia.—On the surface of a leaf only slightly attacked, numerous colourless to pale green creeping hyphæ were found, very irregular in outline, with very few septa and averaging $3\frac{1}{2}$ μ in diameter. Also numerous similarly coloured, oval to elliptic, continuous or uniseptate, and slightly constricted gonidia. The colourless hyphæ were generally branched, septate, thin-walled, and either with elongated or moniliform joints, and the gonidia were continuous, uni- or bi-septate. The dark coloured hyphæ were generally closely septate and constricted at septa, branched, thick-walled, and stouter than the colourless. The gonidia were usually uniseptate or in moniliform chains.

Gemmæ.—The colourless and dark brown clusters of cells were met with germinating, also the mulberry-like clusters of green cells.

Glomeruli.—These were in great abundance, and showed the green clusters of cells composing the wall, and the large and small colourless cells inside imbedded in mucilage, and often connected by an isthmus.

Antennaria-forms.—These were associated with the glomeruli, and seemed to be the most plentiful of all. They were imbedded in clusters among the hyphæ and emitted the colourless spores in great abundance, which remained in masses around the irregularly opening mouth.

No pycnidia were met with, although carefully looked for on a large number of leaves.

Perithecia.—Only immature forms were found of various sizes and at different stages of development. The only one figured (fig. 21) was of fair size ($150 \times 112\ \mu$) dark coloured and oval in shape. On pressure the net-like areas of the wall were very distinct, and by transmitted light were either sea-green to sage-green or brownish. It contained numerous oil-globules and a few asci with paraphyses. The immature asci were shorter and narrower than the average ($39 \times 9\frac{1}{2}\ \mu$) and showed finely granular colourless contents within an inner envelope, and there was a small oval spot towards the centre. In some cases division of the contents had begun, and probably there were some mature forms of perithecia, but I did not happen to come across them (figs. 13-21).

Kew Specimens.—The specimens from Kew did not show very advanced stages. There were colourless to pale green hyphæ, bearing their unicellular or bicellular or simple gonidia, together with Torula-like chains and the quadrate gemmæ. The origin of these latter bodies was very clearly seen. A single cell might germinate and produce hyphæ in one or more directions, or it might divide into two and ultimately into four, each cell giving rise to a filament, but usually one stopped short, so that there were three radiating filaments.

There were also greenish-brown to brown hyphæ with their gonidia and gemmæ and detached joints. Sometimes the coloured hyphæ passed into colourless portions. The glomeruli and spores were also met with, and these, together with the quadrate gemmæ were very characteristic (figs. 22-25).

Burnley Specimens.—The specimens from the Royal Horticultural Gardens, about three miles from Melbourne, showed the ordinary colourless and coloured hyphæ, together with glomeruli, and pycnidia (principally pycnidia), were in great abundance, and seemed to be the prevailing form. There were also immature forms of perithecia, but not as yet in great quantity. The pycnidia varied in colour from leek-green when unopened to yellowish-brown when opened, and the specimen figured (fig. 28) was $526 \times 122\ \mu$. The pycnospores were generally pale green in colour, but sometimes brownish, and the average size was $19 \times 8\mu$. (figs. 26-30).

Other Victorian Specimens.—A few other specimens were obtained from Brighton and Elsternwick, suburbs of Melbourne.

The Brighton specimens were particularly rich in cerato-pycnidia and the antennaria (figs. 31-35), while the Elsternwick specimens showed abundance of pycnidia (figs. 36-37).

South Australian Specimen.

An orange-leaf was forwarded by Mr. Quinn, Inspector under the Vine and Fruit Diseases Act, with the "Sooty Mould" upon it, but not very largely developed.

There were the colourless and coloured hyphæ, gonidia and gemmæ and abundance of glomeruli. The colourless hyphæ were septate, branched, with moniliform or elongated joints, and averaging $3\frac{1}{2}$-$4\frac{1}{2}\ \mu$ broad.

The brown hyphæ were septate, sparingly branched, and varied in breadth from $4\frac{1}{2}$-$7\frac{1}{2}\ \mu$.

The gonidia were similarly coloured and usually simple.

The gemmæ were either clusters of dark brown cells or the green mulberry masses derived from the glomerules. None of the colourless quadrate bodies were met with.

The glomeruli were usually of a yellowish-green to pale green colour, and either isolated or in group.

The presence of brown gemmæ and glomeruli was the predominating feature (figs 38-39).

New South Wales Specimens.

The specimens sent through the courtesy of Mr. Maiden, Govt. Botanist, from trees in the Botanic Gardens, Sydney, were badly infested with scale, but very little of the "sooty mould." There was also upon the scale a considerable quantity of a parasitic fungus known as *Microcera coccophila*, Desm.

In some cases on the upper surface of the leaf there was a very thin stratum of a mud colour, of just sufficient consistency to hold together when peeled off, but no more. It was evidently largely composed of fine dust, and scattered over it were little dark punctiform bodies, very variable in size when looked at with a magnifying glass.

Under the microscope it was seen to consist of a network of colourless hyphæ, and numbers of the spherical or irregularly shaped bodies we have already called glomeruli.

There were very few traces of the greenish-brown hyphæ developed, as the dust had evidently kept the fungus in check.

The colourless or very pale green hyphæ were closely septate, copiously branched and densely crowded so as to form a pavement of cells. The hyphæ were either moniliform or with longer or shorter joints, and bore various gonidia. The diameter of the hyphæ varied considerably, but the broadest was from 6-$7\frac{1}{2}$ μ, and narrowest about 4 μ.

The glomeruli were exceedingly numerous, scattered or in clumps, and were yellowish-green to pallid or even brownish. They varied considerably in shape from spherical to hemispherical or oval, and in size some measuring 250 μ or $\frac{1}{4}$ mm. in diameter. The mulberry-like green clusters and the contents were similar to those already described.

No other reproductive bodies were found.

Even in cases where to the naked eye there is nothing but a patch of dust on the leaf, there are the colourless hyphæ forming a close network of cells, and their gelatinous coating causes the dust to adhere.

As the result of the examination of a large number of specimens I find that the colourless filaments are the earliest formed, branching and intertwining so as to form a close network, adherent to the surface of the leaf.

And of the special reproductive bodies, the glomeruli originate from the colourless hyphæ, appearing in abundance when no other is present. Even when the brown filaments are formed, the glomeruli are seen to be surrounded and not produced by them, as they leave a perfect cavity among the filaments, with the clear colourless layer at its base.

The remaining reproductive bodies are formed from the coloured hyphæ, and apparently appear in the following order when not developed simultaneously :—spermogonia, antennaria, cerato-pycnidia, pycnidia and perithecia.

This specimen served a very useful purpose in determining the origin of the coloured from the colourless hyphæ. At first nothing was observed but colourless hyphæ and numerous glomeruli, and from the constancy of this appearance I was inclined to the opinion that the colourless hyphæ with their reproductive bodies formed an independent fungus, afterwards overlaid by another fungus. But on further search, I found coloured hyphæ arising from the continuation of the colourless hyphæ, and thus the connection was established (figs. 40-44).

General development of sporidia.—Taking an ascus in the young condition and when only about half the size of the adult form, it is found to be filled with finely granular protoplasm, only the short stalk being without it, and there is a minute, slightly oval primary nucleus in the centre (fig. 21).

When further grown the protoplasm recedes from the top, enveloped in its own membrane, and gradually gets further and further away, until in the mature form it may be 9 μ from the top of the ascus. It divides meanwhile into the sporidia, which soon acquire a distinct outline and a few septa. There is usually a slightly knobbed pedicel projecting from the top of the topmost sporidium when immature, apparently indicating a contracted portion of the protoplasmic membrane (fig. 12).

The contents of the at first colourless sporidia soon change into a pale green, increase in size and develop more septa (fig. 10).

This colour next changes to greenish-brown and finally a decided dark-brown like the mycelium, which is the mature form (fig. 12).

Alongside of each other in the same perithecium the three different coloured stages may be seen, but the sporidia in any individual ascus are all of the same colour.

When treated with potassium-iodide-iodine, the contents of the colourless sporidia immediately assumed a beautiful bright canary-yellow tint, but the rest of the ascus remained perfectly hyaline, showing that the epiplasm or glycogen-mass is not present as in Discomycetes, which gives a reddish- or violet-brown reaction. The green and the brown coloured sporidia were unaffected by this reagent. The contents of the paraphyses were also coloured bright canary-yellow, suggestive of their being simply sterile asci. The number of sporidia in each ascus is typically 8, but 4, 5 and 6 were also met with.

Characteristic Distinctions of the Special Reproductive Bodies.

1. *Glomeruli.*—They are generally of a dirty green colour, but may be pallid or greyish, or even brownish, apparently by coatings of dust, &c., and are more or less spherical or hemispherical in shape. They always originate from the colourless or pale green hyphæ, and are the first-formed of the special reproductive bodies. The covering is composed of clusters of mulberry-like green cells, and some of the hyaline cells in the interior are connected with each other by narrow joints. They vary considerably in size, reaching nearly ½ mm. in diameter, and their shape, colour, wall and contents readily distinguish them from others.

2. *Spermogonia.*—The spermogonia resemble somewhat the antennaria in appearance, but differ in contents, while they resemble the cerato-pycnidia in contents, but differ in appearance. They vary considerably in shape and size, and it is difficult to distinguish them from the smaller forms of cerato-pycnidia, but the latter are usually elongated and slender, and have elongated regular cells composing wall, while the former have a net-like surface.

The spermatia so closely resemble cerato-pycnospores that they cannot be distinguished from each other.

3. *Antennaria.*—The spores here are the characteristic feature. They are simple, oval to ovate, with granular contents, and usually 2-guttulate, so that they are distinct from any of the others. The capsules are too variable in shape and size to be relied on for distinction, and they have a net-like surface like the preceding form, but they are often borne laterally on a filament.

4. *Cerato-pycnidia.*—When fully developed they are distinguished from the preceding forms by being very much elongated and often branched, and the regular pattern of their walls; and from the pycnidia proper by the naked, round or oval mouth-opening, but mainly by their contents. The simple, hyaline, rod-like minute spores distinguish the two forms at once.

5. *Pycnidia.*—The pycnidia proper, as already indicated, are distinguished by their usually fringed mouth opening and the coloured tri-septate pycnospores.

6. *Perithecia.*—The perithecia are distinguished from all the others by containing asci accompanied by paraphyses. They sometimes closely resemble spermogonia, although I was generally able to distinguish them by their sea-green or sage-green colour. However, with the exception of the glomeruli, the various reproductive bodies are so variable in size, shape and colour, that the nature of the contents must always be relied upon for final determination.

Connection with scale or other insects.—It is generally believed that this fungus is a saprophyte, since it does not penetrate the leaf in any way, and consequently does not extract nourishment from it. It must live at the expense of something else, and this is supposed to be the honey-dew secreted by certain insects, and associated with which it is invariably found. As a matter of fact I have never found "Sooty Mould" without the accompaniment of scale insects, and they secrete a sweet fluid known as honey-dew. Maskell, in his work on New Zealand Scale Insects, writes :—"In many cases they exude, in the form of minute globules, a whitish, thick, gummy secretion, answering probably to the 'honey-dew' of the Aphididæ. This secretion drops from them on to the plant, and from it grows a black fungus, which soon gives an unsightly appearance to the plant. This fungus or 'smut' is an almost invariable indication that a plant is attacked by insects, and may, indeed, give a useful warning to tree-growers." The occurrence of the fungus on the upper surface of the leaf may be variously accounted for. The upper surface is most readily moistened; the rain and dew are longer retained in the channel over the midrib at the tip. But the main reason evidently is that the honey-dew is dropped there by the coccids generally found on the under surface of the leaves. In the absence of honey-dew the fungus might grow on the accumulations of the excreta of insects, &c., but the general rule is that the fungus follows in the wake of insects, and to get rid of the one you must also get rid of the other.

Since writing the above I have received a note from J. G. O. Tepper, F.L.S., Adelaide, in which he shows how the destruction of honey-eating birds may affect the prevalence of this disease. He says:—"Regarding the 'Sooty Mould' and its prevalence *now* in many localities, it may be mentioned that it appears to have been practically absent, when nature was less disorganised by man, and for a very simple reason. It being due to the sugary exudations of scale insects, &c., coating the trees, its abundance depends upon that of its producers, and this upon the reduction of the sugar-loving, brush-tongued parakeets and other birds which formerly abounded so greatly. These I have often observed myself busy in the *early morning* among the foliage of gums, &c., upon which the honey-dew appeared. Later in the day the ants occupied these in overwhelming numbers, and drove the birds away, protecting the insects and cleaning the foliage.

"Now many plants have developed special *organs* to attract the ants as protectors against birds and animals which feed upon foliage, flowers or unripe fruit, and though rendering service to the plants by reducing superfluous quantities of either, and securing thus the greatest perfection of that remaining (also controlling other insect life), the birds constantly tend to overdo the work at certain critical periods. As our Eucalypts, &c , and many introduced plants have no such organs, they make use of the scales, aphides, &c., to secure indirectly the protective services of the ants, wherever there were birds, &c., available to keep the former under control within safe limits. Therefore the reduction of the birds, &c., by man, stimulated the limitless increase of the scales, aphides, psyllids, aleurodids, &c., and at the same time also the numbers of the ants, which helped to clean away the exudations of those of their pets left by the birds, &c., were greatly diminished. Hence excess of honey-dew insects and of their produce, which is naturally availed of by the low fungoid germ which, under normal conditions, had to be satisfied with the 'crumbs' left by the higher agents "

There is here a somewhat complex relation between the different forms of life used by the plant for protective purposes, and if one of the checks is withdrawn or diminished, the balance is disturbed and disorder ensues.

1. The *Scale* or other insects are used indirectly to attract the ants by their sweet secretions.

2. The *Ants* like a standing army protect the foliage against the attacks of leaf-eating animals.

3. The abundance of honey-eating *Birds* is necessary to keep the scale or other insects within reasonable bounds.

4. The reduction of these birds by man tends to favour the increase of the scale insects and their produce

5. The scale and other insects now get the upper hand, and the ants protecting the insects also favour their increase.

6. The consequence is superabundance of honey-dew, and this is taken advantage of by the germs of the fungus to spread and multiply.

Thus the destruction of the honey-eating birds has brought about an increase of the honey-dew and of the "Sooty Mould" which lives upon it, so that it is not only insectivorous birds which ought to be protected for the benefit of the grower.

It is interesting to observe the appearance of other checks to the spread of the scale or other insects. Here there are two parasitic fungi found respectively on the red and the white orange scale, *Microcera coccophila*, Desm., and *M. rectispora*, Cooke. In

Florida *Aschersonia tahitensis*, Mont., has been found attacking and destroying the larvæ and pupæ of the "Mealy Wing" (*Aleyrodes citri*, R. and H.), and bids fair to be of great use in combating the pest. This latter fungus has also been met with in Queensland on the foliage of a large climber, but no mention is made of its connection with scale or other insects.

Effect on trees—This fungus does not produce any marked injury to the tree at first, as when the "sooty mould" is removed from a leaf the surface beneath is often as green and glossy as a healthy one. The injury is rather of a mechanical nature, and, combined with the scale insects sucking the juices of the plant, there is often considerable damage done. The fungus will interfere with the process of assimilation, by preventing the access of light and the escape of watery vapour and other gases. Indirectly this will hinder the growth of the tree and affect the production of bloom and of fruit. The leaves are less able to stand the effects of drought or other unfavourable conditions, and if the young fruit is attacked by it its development is hindered and it generally remains insipid.

Treatment.—It will be evident from the preceding remarks that the only sensible treatment will be to get rid of the lion's provider; and whatever insect provides the pabulum for the fungus to flourish on, should be dealt with. Mr. French, the Government Entomologist of Victoria, informs me that the principal scale insects attacking the Citrus leaves infested by "sooty mould" are the red scale of the orange (*Aspidiotus coccineus*, Gennad.) and the black scale (*Lecanium oleæ*, Bernard), and for these the treatment he recommends is the kerosene emulsion or resin wash. In a pamphlet issued this year by the U.S. Department of Agriculture on "The principal diseases of Citrous fruits in Florida," by W. T. Swingle and H. J. Webber, spraying with resin wash or fumigation with hydrocyanic acid is said to be very effective.

In the course of this investigation I found a fungus-parasite on the scale insects on leaves with "sooty mould" from N.S.W. This fungus, already known in Europe and hitherto only met with in Queensland, might become a useful ally in the treatment of scale insects, and so I have written a short paper upon this particular form. (*Vide* Appendix, p. 498.)

The fungus itself might be directly treated, but the only sure way is to get rid of the cause of the trouble, viz., the insects.

The following is the formula recommended for the resin wash:—

Resin	20	lbs.
Caustic soda (98%) ...	$4\frac{1}{4}$	„
Fish oil (crude)	3	pints
Water to make	15	gallons.

This is a stock preparation, and when required for use one part thoroughly stirred is added to nine parts of water.

Scientific Description.

CAPNODIUM CITRICOLUM, n.sp.—**Citrus Capnodium.**

Forming black soot-like incrustations, peeling off as a thin membrane, often covering entire surface of leaf. Colourless or pale green hyphæ creeping, copiously branched, septate, up to 6-$8\frac{1}{2}$ μ. broad, intertwining and forming a pavement of cells, giving rise to ascending, short, simple, septate branches, bearing colourless or pale green gonidia, continuous, uni- or bi- septate, spherical, oval or elliptical, slightly constricted, smaller $7\frac{1}{2}$-$9\frac{1}{2}$ × 4-$5\frac{1}{2}$ μ, larger 11-24 × $5\frac{1}{2}$-11 μ; or in moniliform chains.

Coloured hyphæ greenish-brown to dark brown, closely septate, deeply or slightly constricted, sparingly or copiously branched, rigid, $9\frac{1}{2}$-11 μ broad, bearing similarly coloured gonidia, usually elliptical, uniseptate, $7\frac{1}{2}$-16 × $5\frac{1}{2}$-$8\frac{1}{2}$ μ.

Perithecia intermixed with spermogonia, antennaria, cerato-pycnidia and pycnidia, sea-green to sage-green appearing black, oblong to oval or variously shaped, rounded and smooth at free end, with net-like surface, 112-250 × 52-112μ.

Asci cylindrical-clavate; sub-sessile, apex rounded, 8- 6- or 4-spored, 70-80 × 19-20 μ.

Sporidia brown, oblong, sometimes a little fusoid, generally obtuse at both ends, constricted about the middle, 5-6- septate, often with longitudinal or oblique septa, arranged mostly in two ranks but occasionally in three, averaging 21-24 × $8\frac{1}{2}$-$9\frac{1}{2}$ μ.

Paraphyses hyaline or finely granular, elongated-clavate, as long as asci and $9\frac{1}{2}$ μ broad towards apex.

Torula-, Coniothecium-, and Heterobotrys-stages occur.

On living leaves of orange and lemon, particularly on upper surface, also on branches and fruit; all the year round. Victoria, New South Wales, South Australia, Queensland.

There has been a considerable difference, and I might even say change of opinion, as to the true nature and scientific position of the fungus causing the "sooty mould" on Citrus trees. Probably it is due to different fungi in different countries; but as far as I have examined specimens in Australia, they all seem to be referable to the same fungus. Now what is this fungus? Having obtained the various stages of it and abundance of the highest or perithecial stage, there is plenty of material for coming to a definite conclusion.

Meliola penzigi, Sacc., is now recognised as the common "sooty mould" in Europe and America, but the globular perithecia, and the hyaline to brown sporidia 11-12 × 4-5 μ, distinguish it.

Meliola citri, Sacc., causes the disease known in Italy as "mal di cenere," on account of the ashy-grey crust formed by it; but apart from that, the bay-brown perithecia and hyaline sporidia do not agree with this one.

Meliola camelliæ, Sacc., has also been found on the leaves and branches of Citrus trees, but the absence of paraphyses distinguish it at once.

Capnodium citri, Berk., and Desm., has been determined by Dr. Cooke as being found on Citrus leaves in Victoria, but he had no asci and no ascospores to guide him in his determination. The published descriptions are so meagre, in the absence of the most important reproductive organs, that it is rather difficult to get distinctive characters for this species. The original description by Berkeley and Desmazières* mentions the peridia as being elongated, mostly acuminate, conical or lageniform, and the

* Journ. Hort. Soc. Vol. iv. p. 252 (1849).

sporidia as minute, oblong. Then Thuemen* speaks of the perithecia with net-like surface and oblong, very small, bright brown, 2-3-septate spores escaping by a pretty large opening at the apex. Next, Saccardo† describes the perithecia as elongated, often fusoid, $\frac{1}{3}$ mm. high, and spermatia as 7 μ long. As no asci were found, it is doubtful if the bodies referred to were really perithecia, but the 2-3-septate sporidia of Thuemen are very different from the 5-6-septate sporidia of the present form.

Capnodium salicinum, Mont., has been determined by Farlow on orange leaves in America, and there is considerable resemblance in many points, but the asci and sporidia show marked distinctions. The asci measure 40-45 × 24 μ, while here they are on an average 70-80 × 19-20 μ, or nearly double the length. Then the sporidia correspond well in size in both cases, but instead of being tri-septate here, they are 5-6-septate.

Evidently, although the "sooty mould" is so common in Australia wherever Citrus fruits are cultivated, it has not yet been scientifically determined, and I propose naming it *Capnodium citricolum*.

Polymorphism.—Polymorphism literally means many forms, and has reference to the various forms assumed by fungi, especially in their reproductive bodies, in the course of their development. But the change of form may be accompanied by a change of host, and this is distinguished as heterœcism, or there may even be a desertion of the host, and then it is termed lipoxeny. The change of form referred to here occurs consecutively or simultaneously on the same individual, and all the changes were found even on a small portion of the same leaf.

In the present instance there are two different kinds of hyphæ associated—the thin-walled, colourless or slightly coloured hyphæ; and the thick-walled, distinctly coloured hyphæ—and each has its own reproductive bodies.

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* Die Pilze—Fungi pomicoli, p. 53 (1885).

† Syll. Fung. I. p. 78 (1882).

The colourless hyphæ produce gonidia, gemmæ and glomerules; and the coloured hyphæ produce gonidia, gemmæ and the special reproductive bodies known as spermogonia, pycnidia and perithecia.

Detached portions of the hyphæ in both are able to reproduce the fungus, but that need not be specially considered here.

The starting point is with the colourless hyphæ producing gonidia, gemmæ and glomerules; and the final stage is with the coloured hyphæ producing perithecia. The various reproductive bodies of both the colourless and the coloured hyphæ were found respectively in close contiguity, leaving no doubt as to their genetic connection, and the real point at issue is, do the coloured hyphæ grow out of the colourless, or is it simply a case of association? Fortunately, in the specimens from New South Wales, the hyphæ were nearly all colourless or pale green, and it was only very occasionally that a brownish filament was seen. However, in some instances, the pale green or colourless fundamental hyphæ with projecting colourless filaments was observed to gradually pass into a pale brown shade, and from these cells the brownish and comparatively thick-walled hyphæ arose. So that the colourless hyphæ may pass into the coloured, and since the various reproductive bodies may arise from the same or adjoining hyphæ there is genetic connection and not merely association throughout the different stages of this fungus. The forms assumed by the different reproductive bodies are very varied and almost defy general description, so that I have drawn a number of the different shapes in order to give some idea of the wonderful wealth of variety occurring among them. Besides I have only specially examined this fungus during the winter months, and it remains to be seen what are the prevailing forms at other seasons of the year. I hope to examine it monthly, as it occurs with us all the year round, but at present at least seven stages or reproductive phases in the development-cycle of this fungus are known—(1) Gonidial and gemmal stage; (2) Glomeruli stage (*Heterobotrys*); (3) Spermogonial stage; (4) Antennularia stage;

(5) Cerato-pycnidial stage; (6) Pycnidial stage; and (7) Perithecial stage.

My best thanks are due to all those who kindly supplied me with specimens for this investigation, viz.:—Messrs. Carson, Kew; Hunt, Elsternwick; Maiden, Sydney; Neilson, Burnley; Quinn, Adelaide; Turner, Brighton; and Williams, Doncaster.

EXPLANATION OF FIGURES.

(All the figures are magnified 1000 diameters unless otherwise indicated.)

PLATE XXIII., FIGS. 1 *a-b* ; FIG. 2 ; FIGS. 3 *a-g* ; FIGS. 4 *a-d*.

Doncaster specimens—

Fig. 1.—Colourless hyphæ and gonidia.

Fig. 2.—Colourless quadrate gemma with three radiating hyphæ and bearing gonidia.

Fig. 3.—Coloured hyphæ, moniliform and otherwise, bearing gonidia (fig. *c* × 540).

PLATE XXIV., FIGS. 4 *e-g* ; FIGS. 5 *a-c* ; FIGS. 6 *a-o*.

Fig. 4.—Spermogonia with spermatia and pattern of wall (fig. *a* × 540 ; figs. *b* and *e* × 145 ; fig. *f* × 540).

Fig. 5.—Antennaria-form with spores and pattern of wall (fig. *a* × 270).

PLATE XXV., FIGS. 6 *p-r* ; FIGS. 7 *a-h*.

Fig. 6.—Various forms of cerato-pycnidia with spores; the origin is shown in two instances from basal cells (fig. *a* × 270 ; fig. *c* × 540 ; fig. *e* × 540 ; figs. *g-h* × 270 ; figs. *i-m* × 145 ; fig. *n* × 270 ; fig. *o* × 145 ; fig. *p* × 145 ; fig. *q* × 270).

Fig. 7.—Various forms of pycnidia, showing in some cases fringed opening (figs. *a-d* and *f-h* × 145 ; fig. *e* × 270).

PLATE XXVI., FIG. 8 ; FIGS. 9 *a-g*.

Fig. 8.—Various forms of pycnospores—mature and immature; two colourless forms at upper right-hand with finely granular contents.

Fig. 9.—Various forms of perithecia, some of them just peeping out from mass of hyphæ ; and pattern of wall (figs. *a*, *c*, *f*, and *g* × 540 ; fig. *b* × 270 ; figs. *d* and *e* × 145).

PLATE XXVII., FIGS. 10 *a-d* ; FIGS. 11 *a-b* ; FIGS. 12 *a-f*.

Fig. 10.—Asci with paraphyses, one with basal cell to left (figs. *a-d* × 540).

Fig. 11.—Two sporidia detached.

Fig. 12.—Asci containing 4-8 sporidia; the first contained colourless sporidia, the next two pale green sporidia, and the remainder were brown and mature, only the last one of the group being colourless; paraphysis (fig. *f*) also shown.

PLATE XXVIII., FIGS. 13 *a-p*.

Armadale specimens—

Fig. 13.—Colourless hyphæ showing their varied forms, together with gonidia, continuous or 1- to 2-septate (figs. *d* and *n* × 540).

PLATE XXIX., FIGS. 14 *a-b*; FIGS. 15 *a-m* ; FIG. 16 ; FIGS. 17 *a-b* ; FIGS. 18 *a-c*.

Fig. 14.—Quadrate colourless gemmæ (fig. *b* × 540).

Fig. 15.—Various forms of coloured hyphæ and gonidia (fig. *a* × 540).

Fig. 16.—Greenish-brown cluster of cells germinating.

Fig. 17.—Mulberry-like gemmæ.

Fig. 18.—Spores isolated and connected, large and small.

PLATE XXX., FIGS. 19 *a-l* ; FIG. 20; FIGS. 21 *a-c* ; FIGS. 22 *a-i*.

Fig. 19.—Antennaria-forms with spores and portion of netted wall (figs. *a-d* × 540 ; figs. *e-i* and *k* × 270).

Fig. 20.—Immature form of antennaria (× 540).

Fig. 21.—Immature perithecium (fig. *a* × 145) and asci, showing origin of latter from chain of colourless cells.

Kew specimens—

Fig. 22.—Colourless hyphæ and gonidia.

PLATE XXXI., FIG. 23 (ten figures); FIG. 24 (six figures) ; FIGS. 25 *a-b* ; FIG. 26 ; FIGS. 27 *a-c* ; FIGS. 28 *a-b*; FIGS. 29 *a-b* ; FIG. 30 ; FIGS. 31 *a-b*.

Fig. 23.—Quadrate gemmæ with triradiate hyphæ shown to originate from a single cell.

Fig. 24.—Brown hyphæ and gonidia.

Fig. 25.—Glomerulus (fig. *a* × 270) and spores.

Burnley specimens—

Fig. 26.—Quadrate colourless gemmæ (× 270).

Fig. 27.—Pycnidia and pycnospores (fig. *a* × 52 ; fig. *b* × 97).

Fig. 28.—Pycnidium (× 145) and pycnospores more enlarged.

Fig. 29.—Wall of pycnidium formed of elongated, filamentous cells (fig. *a* near the top ; fig. *b* lower down).

Fig. 30.—Green filaments of walls passing into colourless fringe at mouth.

Brighton specimens—

Fig. 31.—Quadrate gemmæ (× 540).

PLATE XXXII., FIGS. 32 *a-b* ; FIGS. 33 *a-g* ; FIG. 34 ; FIGS. 35 *a-b*.

Fig. 32.—Antennaria (× 145) and spores.

Fig. 33.—Cerato-pycnidia and spores (figs. *a*, *b*, *d*, and *e* × 145 ; figs. *c*, *f*, and *g* × 270).

Fig. 34.—Cerato-pycnidium conical and bullet-shaped (× 540).

Fig. 35.—Elongated jointed filaments composing wall of cerato-pycnidium, sometimes long and slender, sometimes short and stout.

Elsternwick specimens—

Fig. 36.—Quadrate gemma (× 540).

Fig. 37.—Upper portion of pycnidium and pycnospores (× 540).

South Australian specimens—

Fig. 38.—Dark brown gemmæ (figs. *b* and *c* × 540).

Fig. 39.—Glomeruli (× 145).

PLATE XXXIII., FIGS. 40 *a-d* ; FIG. 41 ; FIGS. 42 *a-b* ; FIGS. 43 *a-b*.

New South Wales specimens—

Fig. 40.—Branching and gonidia-bearing colourless hyphæ.

Fig. 41.—Colourless and coloured cells and hyphæ. The colourless gradually pass into the pale brown towards the right, and produce thick-walled hyphæ, shown darker in colour.

Fig. 42.—Quadrate gemmæ (× 540).

Fig. 43.—Glomeruli, in chains and in groups (fig. *a* × 145 ; fig. *b* × 52).

PLATE XXXIV. (upper division of Plate), FIGS. 44 *a-h*.

Fig. 44.—Outlines of various isolated glomeruli (fig. *g* × 145).

Note.—The following are the magnifications assigned to Zeiss's Oculars and Objectives :—

Oc.	2.	Obj.	A=52.
,,	4.	,,	A=97.
,,	2.	,,	C=145.
,,	4.	,,	C=270.
,,	2.	,,	F=540.
,,	4.	,,	F=1000.

APPENDIX.

MICROCERA COCCOPHILA, Desm.—Coccus-loving Microcera.

(Plate XXXIV., lower division of Plate.)

Minute, deep brick-red tubercles, rounded or flattened and disc-like on surface, usually in small groups, visible to the naked eye, hard and horny when dry, with short stem-like base.

Hyphæ at base of gonidiophores hyaline, septate, closely compacted, 3-4 μ broad.

Gonidiophores tufted, filiform, elongated (at least 280μ), septate, sometimes slightly constricted at septa, rose-pink in mass, with finely granular, and often vacuolated contents, 4-4½ μ broad.

Gonidia same colour as gonidiophores to hyaline, curved, elongated, usually blunter at free end than attached end, with finely granular, nucleated contents, variously septate, continuous up to 8-septate, average 5-6, size from tip to tip of curve and not actual length 75-103 × 5½-8½ μ.

Parasitic on Red Scale of Orange and Shaddock (*Aspidiotus coccineus*, Gennad.). July, August, &c Botanic Gardens, Sydney, New South Wales (Maiden).

In the original description the gonidiophores are given as 2½ μ thick and the gonidia as hyaline, acute at each end, 3-5-septate and 4-5 μ broad. This European species has only hitherto been found in Queensland, where F. M. Bailey, the Colonial Botanist, observed it on a Coccus infesting the Lemon. Mr. Tryon also refers to it in his "Report on Insect and Fungus Pests" as one of the natural enemies of the Red Orange Scale; and Mr. French, the Government Entomologist here, in his "Handbook of Destructive Insects," calls special attention to it as a possible auxiliary in keeping down the Red Scale, and possibly other scale insects.

So far it has not been met with in Victoria, but I hope to test its efficacy on the Orange Scale shortly,

It is closely allied to *Fusarium*, but the small tubercles differ and it is believed to be a conidial condition of *Sphaerostilbe.*

EXPLANATION OF FIGURES.

Microcera coccophila, Desm.

Fig. 1.—Gonidiophores and gonidia (× 527).

Fig. 2.—Gonidia with from 3-8 septa (× 1000).